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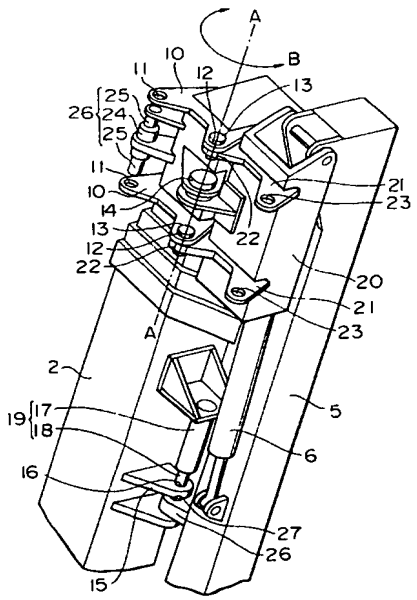
# (54) APPARATUS AND METHOD FOR CONTROLLING THE OPERATION OF REACH TOWER CRANE

(57) A system and a method for operation control of a reach tower crane, in which a horizontal boom can safely and securely be extended or folded by one operator in the cab, and in which even if sensors are out of order, the stability of the crane can be secured. The system comprises a plurality of sensors for detecting condition of an actuator(6) operating an apparatus to extend or fold a horizontal boom(5), a controller(36) for sending a control signal based on signals from the sensors, and hydraulic apparatuses for controlling various actuators in accordance with the control signal. Further, an operation lever and an operation switch are used to extend or fold the horizontal boom(5).

FIG. 3

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## Description

### Technical Field

This invention relates to a system and a method for operation control of a reach tower crane, in particular, a system and a method for operation control of a reach tower crane in which a horizontal boom can safely and easily be extended or folded by one operator in a cab.

### Background Art

A conventional reach tower crane is generally equipped with an arm as shown in, for example, Japanese Utility Model Application Laid-Open No. 63-41092. The arm comprises a vertical boom, and a vertically swingable horizontal boom connected therewith. When the crane travels, the vertical boom is laid, and the horizontal boom is folded so that it is bent on the upper part of the vertical boom, on the other hand, during the crane operation, the vertical boom is erected, and the horizontal boom is swingable upward and downward.

However, when the arm is folded, the vertical boom and the horizontal boom are overlaid on each other to increase their vertical dimension. As a result, while the crane is travelling, the folded arm puts an obstacle to the vision for an operator.

As means to solve such a problem, there has been proposed an apparatus to extend or fold a horizontal boom in a reach tower crane as shown in, for example, Japanese Utility Model Application Laid-Open No. 4-091512.

The reach tower crane is provided with a multiple stage telescopic vertical boom so that it can be swung upward or downward in erecting or laying, and the vertical boom is provided with a multiple stage telescopic horizontal boom swingable upward and downward.

The apparatus secures the vision for an operator while the crane is travelling, by rotating the horizontal boom bent under the vertical boom in the widthwise direction of the vertical boom, and folding it in parallel with a side of the vertical boom to make it laid and to reduce its vertical dimension.

However, such prior art requires manual operation by another operator when extending or folding the horizontal boom outside the cab, and is capable of working only in the condition that the vertical boom is retracted to its shortest length. Accordingly, in a limited space, working by using the prior art faces great difficulties, and is attended with danger.

Further, an operation of setting or removing a securing pin for both the vertical boom and the horizontal boom, and operations of rotating, swinging up and down, and telescopically moving the horizontal boom, respectively, are independently operational. As a result, there are a lot of possibilities that misoperation causes danger, and that an apparatus interferes with another one to cause breakage.

### Disclosure of Invention

The present invention is made in order to eliminate the defects of the prior art. It is an object of the present invention to provide a system and a method for operation control of a reach tower crane which enable a horizontal boom to safely and securely be extended or folded by one operator in a cab, and to easily work also in a limited space.

The first aspect of the present invention provides a system to control the operation of a reach tower crane, comprising a plurality of sensors to detect the condition of various actuators in operating an apparatus to extend or fold a horizontal boom, a controller to determine and transmit a control signal based on signals from the plurality of sensors, and hydraulic apparatuses to control the operation of the various actuators on receiving the control signal.

The plurality of sensors may comprise a derricking angle detection sensor to detect the derricking angle of a vertical boom, a length detection sensor to detect that the vertical boom is retracted to its shortest length, locking and unlocking detection sensors to detect locking and unlocking by locking apparatuses to fix both the vertical boom and the horizontal boom, a turning angle detection sensor to detect the turning angle of a turning motor to extend or fold the horizontal boom, a derricking angle detection sensor to detect a derricking angle of the horizontal boom, and a length detection sensor to detect that the horizontal boom is retracted to its shortest length.

The locking apparatuses may comprise a first locking apparatus to fix the horizontal boom folded in parallel with a side of the vertical boom, and a second locking apparatus to fix a joint bracket equipped with the extended horizontal boom provided on the top of the vertical boom.

Further, in the cab, operation levers and operation switches may be provided to enable manually-operated control of extending or folding the horizontal boom. The operation levers comprise one telescopic operation lever, and one derricking operation lever. The telescopic operation lever controls telescopic motion of the vertical boom, telescopic motion of the horizontal boom, operation of the rotary motor, and operation of the second locking apparatus, while the derricking operation lever controls derricking of the vertical boom and the horizontal boom. The operation switches may comprise a selector switch for changeover of the vertical boom control and the horizontal boom control, and an operation switch for operating the first locking apparatus.

Still further, a hydraulic circuit to control telescopic motion of the vertical boom and the horizontal boom may be provided with an unloader valve therein so that the unloader valve can stop stretching the vertical boom and the horizontal boom on receiving a signal from the controller when the sensor or the like is out of order.

The above-described configuration enables an operator to start a subsequent operation after verifying

operation of each part of the crane by checking each sensor, so that the horizontal boom can be extended or folded by the one operator, and interference with misoperated apparatuses does not occur. Since the configuration also has the unloader valve to stop stretch of the booms, when the sensor or the like is out of order, the boom can be shortened and cannot be stretched to secure safety.

The second aspect of the present invention provides a system for operation control of a reach tower crane comprising:

a three position operating valve having a hydraulic power source port, a tank port, and two actuator ports A and B;

a first solenoid selector valve having the first position to connect either the actuator port A or B to a second solenoid selector valve and a first actuator and to connect the other port to a third solenoid selector valve, by exciting the first solenoid selector valve, and the second position to respectively connect the ports A and B to a second actuator by degaussing the first solenoid selector valve;

a second solenoid selector valve having the first position to connect the first solenoid selector valve to a third actuator by exciting the second solenoid selector valve, and having the second position to connect the second solenoid selector valve to a check valve to block a flow to the third actuator by degaussing it; and

a third solenoid selector valve having the first position to connect the first solenoid selector valve to the first actuator by exciting the third solenoid selector valve, and the second position to connect the first solenoid selector valve to the third actuator by degaussing the third solenoid selector valve, wherein the solenoid of the first solenoid selector valve is excited when one end of the first actuator is detected, and the solenoid is degaussed by an operation-allowable signal sent to the other end of the first actuator;

the solenoid of the second solenoid selector valve is excited when one end of the third actuator is detected, and the solenoid is degaussed when the other end of the first actuator is detected;

the solenoid of the third solenoid selector valve is degaussed when one end of the third actuator is detected, and the solenoid is excited when one end of the first actuator is detected, and the solenoid is degaussed by the operation-allowable signal sent to the other end of the first actuator and the solenoid is excited when the other end of the first actuator is detected.

The first actuator is a cylinder to drive a lock pin to lock a horizontal boom on a vertical boom when the horizontal boom is extended, the second actuator is a cylinder to telescopically move the horizontal boom, and the third actuator is a motor to extend or fold the horizontal boom. The first actuator may have the locking position at one end, and the unlocking position at the other end. The third actuator may have its one end for the extending position, and the other end for the folding position.

The third aspect of the present invention provides a method for operation control of a reach tower crane, wherein the method comprises the steps of:

(a) starting to unlock by a first locking apparatus after a vertical boom is operated to be erected and the derricking angle detection sensor detects that the vertical boom is erected at a predetermined derricking angle;

(b) starting to turn a horizontal boom by driving a turning motor after a detection sensor detects that the unlocking is completed by the first locking apparatus;

(c) starting to lock by a second locking apparatus after a turning angle detection sensor detects that the turning motor has turned to a predetermined turning angle;

(d) starting to erect the horizontal boom after a detection sensor detects that the locking is completed by the second locking apparatus; and

(e) starting to telescopically move and derrick the horizontal boom after the derricking angle detection sensor detects that an angle of the horizontal boom with respect to ground reaches horizontal.

The forth aspect of the present invention provides a method for operation control of a reach tower crane, wherein the process of folding a horizontal boom comprises the steps of:

(a) starting to lay the horizontal boom after the vertical boom and the horizontal boom are retracted and a length detection sensor detects that both of the booms are retracted to their shortest length as well as a derricking angle detection sensor detects that the vertical boom is erected at the predetermined derricking angle;

(b) starting to unlock by a second locking apparatus after the derricking angle detection sensor detects that the horizontal boom is at a maximum angle of laying;

(c) starting to turn the horizontal boom by driving a turning motor after a detection sensor detects that the locking is completed by the second locking apparatus;

(d) starting to lock by a first locking apparatus after a turning angle detection sensor detects that the turning motor has turned to a predetermined turning angle; and

(e) starting to lay the vertical boom after the detection sensor detects that locking is completed by the first locking apparatus.

The fifth aspect of the present invention provides a method for operation control of a reach tower crane, wherein the horizontal boom is derricked after stretching the vertical boom to a predetermined length.

As shown by the system and the method for operation control of a reach tower crane as disclosed in the

second to fifth aspects of the present invention, in the operation of extending the horizontal boom from its folded state, the third actuator, which is the motor to extend or fold the horizontal boom, is operated to the extending position, and the first actuator, which is the cylinder to drive the lock pin, is subsequently operated to the locking position.

When the first actuator is operated to the locking position, the second actuator is capable of being stretched, which enable the cylinder to telescopically move the horizontal boom. Further in the operation of folding the horizontal boom from its extended state, the second actuator is firstly contracted. Subsequently, when the first actuator is operated to the unlocking position by the operation-allowable signal to the other end of the first actuator which is the cylinder to drive the lock pin locking the horizontal boom on the vertical boom, the locking by the first actuator is unlocked, and the third actuator, which is the motor to extend or fold the horizontal boom, is successively drove to the folding position. As described above, one operating valve is capable of successively operating the three actuators.

## Brief Description of Drawings

FIG.1 is a schematic side view illustrating an operational state of a wheel-drive reach tower crane as an embodiment in accordance with the present invention.

FIG.2 is a perspective view illustrating a travelling state of the wheel-drive reach tower crane as the embodiment.

FIG.3 is a perspective view from the arrow C as shown in FIG.2, illustrating a coupling part of the horizontal boom and the vertical boom in the reach tower crane.

FIG.4 is a side view illustrating a state of the reach tower crane when starting to fold the horizontal boom in the embodiment.

FIG.5 is part of a hydraulic circuit illustrating operation control system to extend or fold the horizontal boom in the embodiment.

FIG.6 is a hydraulic circuit connecting to the hydraulic circuit as shown in FIG.5, showing another part of the operation control system.

FIG.7 is a detail hydraulic circuit of a main operating valve to telescopically move the boom as shown in the embodiment.

FIG.8 is a configurative view illustrating operation levers, operation switches, and so on, provided in a cab of the reach tower crane in the embodiment.

FIG.9 is a flow chart showing the first method for operation of extending the horizontal boom in the embodiment.

FIG.10 is a flow chart showing the second method for operation of extending the horizontal boom in the embodiment.

FIG.11 is the first half of a flow chart showing operation of folding the horizontal boom in the embodiment.

FIG.12 is the latter half of the flow chart connected to the first half of FIG.11, showing the operation of folding the horizontal boom in the embodiment.

FIG.13 is an explanatory side view illustrating the reach tower crane erecting and telescopically moving the horizontal boom after stretching the vertical boom.

## Best Mode for Carrying Out the Invention

With respect to a system and a method for operation control of a reach tower crane in accordance with the present invention, a preferred embodiment is described below, referring to the attached drawings.

Referring to FIG.1, a vertical boom 2 is provided on a body 1 so as to be derricked, and operated by a vertical boom derricking cylinder 3. A vertical boom telescopic cylinder 4 is included in the vertical boom 2 as shown in FIG.5, which telescopically moves the vertical boom 2 at multiple stages. On the other hand, a horizontal boom 5 is provided on the head of the vertical boom 2 so that it can be derricked, and operated by a horizontal boom derricking cylinder 6. A horizontal boom telescopic cylinder 7 is included in the horizontal boom 5 as shown in FIG.6, which telescopically moves the horizontal boom 5 at multiple stages.

As can be seen from FIG.2, in the reach tower crane, the vertical boom 2 is laid on the body 1, and the horizontal boom 5 is folded as it is bent in parallel with a side of the vertical boom 2, so that the vision for an operator is not obstructed by the booms.

Referring to FIG.3, there is shown a coupling part of the horizontal boom 5 and the vertical boom 2. On the head of the vertical boom 2, two brackets 10 are axially fixed in parallel. On both ends of the brackets 10, there are provided holes 11 and 12, respectively. A joint bracket 20 has two brackets 21 fixed in parallel thereon. On both ends of the brackets 21, there are provided holes 22 and 23, respectively. Further, the hole 12 of the vertical boom 2 and the hole 22 of the joint bracket 20 are engaged in each other, and are connected by a pin 13 so that they can be turned. A turning motor 14 is provided along the turning axis A-A of the pin 13, and turns the joint bracket 20 as shown by the arrow B. On the vertical boom 2, in a position suitable for the hole 11, there is provided the second locking cylinder 24 of the second locking apparatus 26 including a connecting pin 25. On the joint bracket 20, the horizontal boom 5 and the horizontal boom derricking cylinder 6 are provided so as to be derricked. A bracket 26 with a hole 27 is fixed on a side of the horizontal boom 5. As shown in FIG.3, in a state that the horizontal boom 5 is folded as it is bent on a side of the vertical boom 2, the bracket 26 fits the hole 16 of the bracket 15 fixed on a side of the vertical boom 2. On a side of the vertical boom 2, in a position fitting a hole 16, there is provided the first locking cylinder 17 of the first locking apparatus 19 including a connecting pin 18.

Effects of the present invention is described below. From an operational state of the reach tower crane as

shown in FIG.1, in order for the horizontal boom 5 to be folded as bent in parallel with a side of the vertical boom 2 as shown in FIG.2, the vertical boom 2 and the horizontal boom 5 are shortened to their shortest length as shown in FIG.4, and a derricking angle $\alpha$ of the vertical boom 2 is made between 75° and 83°. Then the above turning axis A-A is substantially vertical, and torque required by the turning motor 14 is minimized. Subsequently, when the angle $\beta$ reaches a predetermined value by laying the horizontal boom 5 using the horizontal boom derricking cylinder 6, the second locking cylinder 24 is operated to disengage the connecting pin 25, and the turning motor 14 is drove to turn the horizontal boom 5 in the direction of the arrow B as shown in FIG.3.

When the horizontal boom 5 is bent in parallel with the vertical boom 2 as well as the hole 16 of the bracket 15 on the vertical boom 2 is fit for the hole 27 of the bracket 26 on the horizontal boom 5, the pin 18 is engaged in the holes 16 and 27 by operating the first locking cylinder 17 to fix the vertical boom 2 and the horizontal boom 5. Subsequently, the vertical boom 2 is laid to be in a state as shown in FIG.2. In order to turn the state of the boom folded to the operational state, the above-described process may be reversed.

Referring to FIG.5 and FIG.6, pipes M and N, and lines a, b, c, d, e, and f are respectively connected to another one.

As shown in FIG.5, there are shown an oil pump 30 and an oil tank 31. The first locking operation switch 32 is to manually operate the first locking cylinder 17, and has the three positions of neutral(N), locking(R), and unlocking(U). The first locking cylinder 17 is provided with a locking completion detection limit switch 40, and an unlocking completion detection limit switch 41. The first locking operation switch 32 is connected to both a locking-unlocking selector valve 50 of the first locking cylinder and a selector valve 51 to change over the first locking cylinder and the boom. The selector valve 51 is provided in a discharge circuit of the oil tank 30, where the selector valves are all electromagnetic. The selector valve 51 to change over the first locking cylinder and the boom closes a circuit to the first locking cylinder 17 when the first locking operation switch 32 is in the position N, and opens a circuit to the boom.

There are further shown a boom derricking main operation valve 60 and a boom telescopic motion main valve 61, which have manually operated levers 62 and 63. The boom derricking main operation valve 60 controls both the vertical boom derricking cylinder 3 and the horizontal derricking cylinder 6, while the boom telescopic motion main valve 61 controls both the vertical boom telescopic cylinder 4 and the horizontal telescopic cylinder 7. A vertical boom derricking on-off selector valve 52 is provided in a circuit connecting the vertical boom derricking cylinder 3 and the boom derricking main operation valve, while a horizontal boom on-off selector valve 53 is provided in a circuit connecting the vertical boom derricking cylinder 6 and the boom derricking main operation valve 60.

A vertical boom telescopic motion on-off selector valve 54 is provided in a circuit connecting the vertical boom telescopic cylinder 4 and the boom telescopic motion main operation valve 61. A selector valve 55 for controlling both the horizontal boom telescopic cylinder 7 and the turning motor 14 is provided in other output circuits M and N of the boom telescopic motion main operation valve 61. The vertical boom telescopic cylinder 4 is provided with a length detection sensor 42 for detecting that the vertical boom 2 is retracted to shortest.

Referring to FIG.6, there is shown a selector valve 56 to select the horizontal boom telescopic motion or the turning motor driving. The selector valve 56 is provided in the circuits M and N. This selector valve 56 is connected to both a circuit connecting with the horizontal boom telescopic cylinder 7 and circuits and turning motor drive circuits 70 and 71. This horizontal boom telescopic cylinder 7 is provided with a length detection sensor 43. A selector valve 57 to select extending or folding in connection with the turning motor 14 is provided in a circuit connecting a circuit 70 and the turning motor 14, while an one-way valve 73 is provided in the position A of the selector valve 57. A branch circuit 72 of the circuit 70 is connected to one chamber of the second locking cylinder 24.

The circuit 71 is connected to both the other chamber of the second locking cylinder and the turning motor 14 through a selector valve 58 to select the second locking cylinder or the turning motor. On the second locking cylinder 24, there are mounted a locking completion detection limit switch 44 and an unlocking completion detection limit switch 45. On the turning motor 14, there are mounted a folding completion detection limit switch 46 and an extending completion detection switch 47.

A vertical-horizontal selector switch 33 is a manually operated switch to change over operating of the vertical boom 2 and the horizontal boom 5. Operating the selector switch 33 changes over the boom derricking main operation valve 60 and the boom telescopic motion main operation valve 61 to be in the vertical boom operation or the horizontal boom operation. A derricking angle detection sensor 34 detects a derricking angle of the vertical boom 2, and a derricking angle detection sensor 35 detects that of the horizontal boom 5. A controller 36 connects with the limit switches 40 to 47, the derricking angle detection sensors 34 and 35, and the selector switch 33. The controller 36 receives their input, and connects with the selector valves 52 to 58 to send control signals.

Referring to FIG.7, the boom telescopic motion main operation valve 61 is pilot-controlled, and has therein an unloader valve 66 provided in one of circuits connecting both a pilot control valve equipped with the operation lever 63 to telescopically move the boom and a directional control valve 65. The unloader valve 66 is connected to the controller 36. There are further shown

the hydraulic pump 30 and the oil tank 31. Operating the operation lever 63 to the side C of the pilot control valve 64 enables the directional control valve 65 to move in the position C so that the boom is stretched, oppositely, operating the operation lever 63 to the side D enables the directional control valve 65 to move in the position D so that the boom is shortened.

Explaining the operation of the main operation valve 61, normally, the unloader valve 66 is in the position A by a signal from the controller 36 so as to enable both operation of stretching and shortening the boom. However, when operating the boom to be extended, folded, or locked, malfunction of the limit switch or the like causes the controller 36 to detect an abnormal state and send a control signal to move the unloader valve 66 in the position B. The directional control valve 65 accordingly can move in the position D, but cannot move in the position C. In other words, since the boom can be shortened but cannot be stretched, stability during the malfunction of the limit switch or the like is maintained.

Referring to FIG.8, there are provided the boom derricking operation lever 62 and an auxiliary winch operation lever 81, to the right of an operator seat 80, while there are provided a main winch operation lever 82, a swing operation lever 83, and the boom telescopic operation lever 63, to the left of the seat. On the other hand, there are provided the first locking operation switch 32, the vertical-horizontal selector switch 33, and an indicator panel 37, to the front of the seat. In accordance with signals from the controller 36, the indicator panel 37 indicates completion of locking or unlocking by the first locking apparatus 19, completion of unlocking by the second locking apparatus 26, completion of folding by the turning motor 14, derricking angles of the vertical boom 2 and the horizontal boom 5, and completion of shortening both the vertical boom 2 and the horizontal boom 5 to shortest.

Operation of extending and folding the horizontal boom is described using the flow chart of FIG.9, based on the circuits in FIG.5 and FIG.6, as follows:

In Step 100 as an initial state, the horizontal boom 5 is folded, and the vertical-horizontal selector switch 33 is changed over to the state of operating vertical boom. Consequently, the selector valves 52 and 54 are in the position A, while the selector valves 53 and 55 are in the position B. The first locking apparatus 19 is in its locking state, the first locking operation switch 32 is in the position N, and the selector valve 51 is in the position A. A derricking angle of the horizontal boom 5 shows a maximum angle of laying, the selector valve 56 is changed over to the position B by a signal sent from the controller 36. The second locking apparatus 26 is in its unlocking state, the selector valve 57 is changed over to the position B, based on a signal from the limit switch 45.

In Step 101, an operator erects the vertical boom 2 by operating the boom derricking operation lever 62. In the following Step 102, from the indicator panel 37, the operator verifies whether a derricking angle of the vertical boom 2 is greater than 75° or not, based on a signal from the derricking angle sensor 34. If the angle is greater than 75°, the operator proceeds to the following Step 103. If not, the operator returns to the Step 101.

In Step 103, the operator changes over the first locking switch 32 in the position U. Then, the selector valves 50 and 51 change over to the position B. Pressure oil from the hydraulic pump 30 shortens the first locking cylinder 17 to enable unlocking by the first locking apparatus 19. In Step 104, from the indicator panel 37, the operator verifies whether unlocking by the first locking apparatus 19 is completed or not, based on a signal from the limit switch 41. If the unlocking is completed, the operator proceeds to the following Step 105. If not, the operator returns to the Step 103.

In Step 105, the operator changes over the first locking switch 32 to the position N, then the selector valve 51 changes over to the position A. In Step 106, the operator changes over the vertical-horizontal switch 33 to horizontal. Then, the selector valves 52 and 54 change over to the position B, and the selector valve 55 changes over to the position A. In Step 107, the operator operates the boom telescopic motion lever 63 to the extending direction. The pressure oil from the oil pump 30 drives the turning motor in the turning direction through the circuits 70 and 71, passing the selector valves 55, 56, 57, and 58.

In Step 108, when the turning motor 14 turns at a predetermined angle whereby extending the horizontal boom is completed, in accordance with a signal from the limit switch 47, the controller 36 sends control signals to change over the selector valve 57 to the position A, and change over the selector valve 58 to the position B. The pressure oil stretches the second locking cylinder 24 through the circuits 71 and 72, passing the selector valve 58, so as to fix the joint bracket 20 on the vertical boom 2.

In Step 109, from the indicator panel 37, the operator verifies whether locking by the second locking apparatus 26 is completed or not, based on a signal from the limit switch 44. If the locking is completed, the operator proceeds to the following Step 110. If not, the operator returns to the Step 107. When the locking by the second locking apparatus is completed, based on a signal from the limit switch 44, the selector valve 53 changes over to the position A, so that the horizontal boom derricking cylinder 6 turns to be operational. In Step 110, the operator operates the derricking operation lever 62 to erect the horizontal boom 5.

In Step 111, the operator verifies whether an angle of the horizontal boom 5 with respect to ground is equal to or greater than 0° or not, based on a signal from the derricking angle sensor 35. If the angle is equal or greater, the operator proceeds to the following Step 112. If not, the operator returns to Step 110. When the angle of the horizontal boom with respect to ground is equal to or greater than 0°, on receiving a signal from the derricking angle detection sensor 35, the controller 36 sends control signals to change over the selector valve 56 to the position A, so that the horizontal boom

telescopic cylinder 7 turns to be operational. In Step 112, the operator operates to telescopically move the horizontal boom 5. In Step 113, extending the horizontal boom 5 is completed.

FIG.10 is a flow chart showing the second method for operation of extending, and is the same as the flow chart showing the above-described first method, up to the Step 108. Explanation of the same Steps are accordingly omitted.

In Step 109, from the indicator panel 37, the operator verifies whether locking by the second locking apparatus 26 is completed or not, based on a signal from the limit switch 44 of the second locking cylinder. If the locking is completed, the operator proceeds to the following Step 110. If not, the operator returns to the Step 107. When the locking by the second locking apparatus 26 is completed, based on a signal from the limit switch 44, the selector valve 53 changes over, so that the horizontal boom derricking cylinder 6 turns to be operational.

In Step 110, the operator changes over the vertical-horizontal selector switch to the vertical. Then, the selector valves 52 and 54 change over to the position A, while the selector valves 53 and 55 change over to the position B. In Step 111, the operator operates the boom telescopic motion lever 63 to stretch the vertical boom 2. In Step 112, the operator changes over the vertical-horizontal selector switch 63 to the horizontal. Then, the selector valves 53 and 55 change over to the position A, while the selector valves 52 and 54 change over to the position B.

In Step 113, the operator operates the boom derricking operation lever 62 to erect the horizontal boom 5. In Step 114, the operator verifies whether a derricking angle of the horizontal boom 5 with respect to ground is equal to or greater than 0° or not. If the angle is equal or greater, the operator proceeds to the following Step 115. If not, the operator returns to the Step 113. When the derricking angle of the horizontal boom 5 with respect to ground is equal to or greater than 0°, on receiving a signal from the derricking angle detection sensor 35, the controller 36 sends a control signal to change over the selector valve 56, so that the horizontal boom telescopic cylinder 7 turns to be operational. In Step 115, the operator operates to telescopically move the horizontal boom 5. In Step 116, extending the horizontal boom 5 is completed.

In accordance with the second method, in a limited space, easy operation of erecting the horizontal boom can be realized.

Operation of folding the horizontal boom 5 is described in accordance with the flow charts of FIG.11 and FIG.12, as follows:

In Step 200, initially in a working state that the vertical boom 2 is erected and stretched while the horizontal boom 5 is erected and stretched. On the other hand, the vertical-horizontal selector switch 33 is changed over to the state of operating the horizontal boom. Consequently, the selector valves 53 and 55 are in the position B, while the selector valves 53, 55 and 56 are in the position A. The first locking cylinder 17 is shortened as its unlocking state, the first locking operation switch 32 is changed over to the position N, the selector valve 50 is in the position B, and the selector valve 51 is in the position A. On the other hand, the second locking cylinder 24 is stretched as its locking state, and the selector valve 57 is in the position A and the selector valve 58 is in the position B, based on a signal from the limit switch 44.

In Step 201, the operator operates the boom telescopic operation lever 63 to shorten the horizontal boom telescopic cylinder 7 so as to shorten the horizontal boom 5. In Step 202, from the indicator panel, the operator verifies whether the horizontal boom 5 is shortened to shortest or not, based on a signal from the length detection sensor 43. If the horizontal boom 5 is shortened, the operator proceeds to the following Step 203. If not, the operator returns to the Step 201. In Step 203, the operator operates the boom derricking operation lever 62 to shorten the horizontal boom derricking cylinder 6 so as to lay the horizontal boom 5.

In Step 204, from the indicator panel 37, the operator verifies whether the horizontal boom 5 is at a maximum angle of laying or not, based on a signal from the derricking angle detection sensor 35. If the horizontal boom 5 is at the maximum angle, the operator proceeds to the following Step 205. If not, the operator returns to the Step 203. When the horizontal boom 5 is at the maximum angle, in accordance with a signal from the derricking angle detection sensor 35, the controller 36 sends a control signal to change over the selector valve 56 to the position B. In Step 205, the operator changes over the vertical-horizontal selector switch 33 to the vertical.

In Step 206, the operator operates the boom telescopic operation lever 63 to shorten the vertical boom telescopic cylinder 4 so as to shorten the vertical boom 2. In Step 207, from the indicator panel 37, the operator verifies whether the vertical boom is shortened to shortest or not. If the vertical boom is to shortest, the operator proceeds to the following Step 208. If not, the operator returns to the Step 206. In the Step 208, the operator operates the boom derricking operation lever 62 so that a derricking angle of the vertical boom 2 can be greater than 75°. In Step 209, from the indicator panel 37, the operator verifies whether the derricking angle of the vertical boom 2 is greater than 75° or not, based on a signal from the derricking angle detection sensor 34. If the derricking angle is greater, the operator proceeds to the following Step 210. If not, the operator returns to the Step 208.

In Step 210, the operator changes over the vertical-horizontal selector switch to the horizontal. In Step 211, when the operator operates the boom telescopic operation lever 63 to the direction of unlocking by the second locking apparatus 26, pressure oil from the oil pump 30 shortens the second locking cylinder 24 so as to enable unlocking by the second locking apparatus 26 through the circuits 70, 71 and 72, passing the selector valves

55, 56 and 58. On the other hand, another oil to the turning motor 14 via the selector valve 57 from the circuit 70 is blocked by the one-way valve 73.

In Step 212, when the second locking cylinder 24 is completely shortened to enable unlocking by the second locking apparatus, based on a signal from the limit switch 45, the controller 36 send control signals to change over the selector valves 53 and 57 to the position B and to change over the selector valve 58 to the position A. Pressure oil drives the turning motor 14 in the direction of folding through the circuits 70 and 71, passing the selector valves 57 and 58. In Step 213, from the indicator panel 37, the operator verifies whether the turning motor 14 turns at a predetermined angle or not, based on a signal from the limit switch 46. If the turning motor turns at the angle, the operator proceeds to the following Step 214. If not, the operator returns to the Step 211.

In Step 214, the operator changes over the first locking switch 32 to the position R. The selector valve 50 changes over to the position A, and the selector valve 51 changes over to the position B. Pressure oil stretches the first locking cylinder 17 via the selector valves 50 and 51 so as to enable locking by the first locking apparatus 19. In Step 215, from the indicator panel 37, the operator verifies whether locking by the first locking apparatus is completed or not, based on a signal from the limit switch 41. If the locking is completed, the operator proceeds to the following Step 216. If not, the operator returns to the Step 214.

In Step 216, the operator changes over the first locking operation switch 32 to the position N, and changes over the selector valve 51 to the position A.

In Step 217, the operator changes over the vertical-horizontal selector switch 33 to the vertical. The selector valves 52 and 54 change over to the position A, and the selector valves 53 and 55 change over to the position B. In Step 218, the operator operates the boom derricking operation lever 62 to lay the vertical boom 2. In Step 219, the folding is completed.

Referring to FIG.13, there is shown an embodiment of the operation control method of the reach tower crane erecting and telescopically moving the horizontal boom after stretching the vertical boom, in a place where a building or the like is in proximity to the crane.

As stated in the foregoing, the present invention comprises as described above, and is such that a subsequent operation starts after verifying the operation of each actuator by using each sensor. In accordance with the present invention, one operator in the crane cab is able to safely and firmly extend or fold the horizontal boom, and operate the crane to work in a limited space. The present invention further provides the operation control system and method for extending or folding the horizontal boom without losing stability of the crane.

## Industrial Applicability

The present invention is useful as the system and the method for operation control of the reach tower crane in which the horizontal boom can safety and firmly be extended or folded by one operator, the crane can be operated in a limited space, and stability of the crane cannot be lost when a part such as the sensor is out of order.

## Claims

1. A system for operation control of a reach tower crane having a swingable horizontal boom connected with the head of a vertical boom capable of being derricked and telescopically moved at multiple stages so that the horizontal boom can telescopically moved at multiple stages and be derricked, in which said horizontal boom can be folded such that the horizontal boom is turned in the widthwise direction of said vertical boom and laid in parallel to a side of said vertical boom, said system comprising:

   a plurality of sensors for detecting conditions of various actuators operating an apparatus to extend or fold said horizontal boom;

   a controller for sending a predetermined control signal on determining said control signal in accordance with a signal from said sensor; and

   hydraulic apparatuses for controlling said various actuators, said apparatuses operating in accordance with said predetermined control signal sent from said controller.

2. A system for operation control of a reach tower crane according to claim 1, said plurality of sensors comprising:

   a sensor for detecting a derricking angle of said vertical boom;

   a length detection sensor for detecting that said vertical boom is retracted to its shortest length;

   sensors for detecting locking or unlocking by locking apparatuses fixing said horizontal boom and said vertical boom;

   a sensor for detecting a turning angle of a turning motor for extending or folding said horizontal boom;

   a sensor for detecting a derricking angle of said horizontal boom; and

   a length detection sensor for detecting that said horizontal boom is retracted to its shortest length.

3. A system for operation control of a reach tower crane according to claim 2, said locking apparatuses comprising:

   a first locking apparatus fixing said horizontal boom folded as laid in parallel to a side of said vertical boom; and

a second locking apparatus for fixing a joint bracket provided with said horizontal boom connected with the head of said vertical boom so that said horizontal boom is extended.

4. A system for operation control of a reach tower crane according to claim 1, said system further comprising a cab provided with operation levers and operation switches to enable operation control in connection with extending or folding said horizontal boom.

5. A system for operation control of a reach tower crane according to claim 4, wherein:

said operation levers comprises one telescopic operation lever and one derricking operation lever,

said telescopic operation lever controlling telescopic motion of said vertical boom, telescopic motion of said horizontal boom, operation of said turning motor, and operation of said second locking apparatus, and

said derricking operation lever controlling derricking of said vertical boom and said horizontal boom; and

said operation switches comprises

a selector switch for selecting control of said vertical boom or control of said horizontal boom, and

an operation switch for operating said first locking switch.

6. A system for operation control of a reach tower crane according to claim 1, said system further comprising hydraulic circuits for controlling telescopic motion of said vertical boom and horizontal boom, wherein said hydraulic circuits is provided with unloader valves to stop operation of stretching said vertical boom and said horizontal boom in accordance with a signal from said controller when said sensor or the like is out of order.

7. A system for operation control of a reach tower crane, comprising:

a three position operating valve having a hydraulic power source port, a tank port, and two actuator ports A and B;

a first solenoid selector valve having the first position to connect either said actuator port A or B to both a second solenoid selector valve and a first actuator, and to connect the other port to a third solenoid selector valve, by exciting said first solenoid selector valve, and the second position to respectively connect said ports A and B to a second actuator by degaussing said first solenoid selector valve;

a second solenoid selector valve having the first position to connect said first solenoid selector valve to a third actuator by exciting said second solenoid selector valve, and having the second position to connect said second solenoid selector valve to a check valve to block a flow to said third actuator by degaussing it; and

a third solenoid selector valve having the first position to connect said first solenoid selector valve to said first actuator by exciting said third solenoid selector valve, and the second position to connect said first solenoid selector valve to said third actuator by degaussing said third solenoid selector valve, wherein

the solenoid of said first solenoid selector valve is excited when one end of said first actuator is detected, and the solenoid is degaussed by an operation-allowable signal sent to the other end of said first actuator;

the solenoid of said second solenoid selector valve is excited when one end of said third actuator is detected, and the solenoid is degaussed when the other end of said first actuator is detected; and

the solenoid of said third solenoid selector valve is degaussed when one end of said third actuator is detected, and the solenoid is excited when one end of said first actuator is detected, and the solenoid is degaussed by said operation-allowable signal sent to the other end of said first actuator and the solenoid is excited when the other end of the first actuator is detected.

8. A system for operation control of a reach tower crane, according to claim 7, wherein:

said first actuator is a cylinder for driving a lock pin to lock said horizontal boom on said vertical boom when said horizontal boom is extended;

said second actuator is a cylinder for telescopically moving said horizontal boom; and

said third actuator is a motor for extending or folding said horizontal boom,

said first actuator has the locking position at one end, and the unlocking position at the other end, and

said third actuator has the extending position at one end, and the folding position at the other end.

9. A method for operation control of extending a horizontal boom in a reach tower crane having an apparatus for extending or folding said horizontal boom, said method comprising the steps of:

(a) starting to unlock by a first locking apparatus after a vertical boom is operated to be erected and the a derricking angle sensor detects that said vertical boom is erected at a predetermined derricking angle;

(b) starting to turn said horizontal boom by driving a turning motor after a detection sensor detects that the unlocking is completed by said first locking apparatus;

(c) starting to lock by a second locking apparatus after a turning angle detection sensor detects that said turning motor has turned to a predetermined turning angle;

(d) starting to erect said horizontal boom after a detection sensor detects that the locking is completed by said second locking apparatus; and

(e) starting to telescopically move and derrick said horizontal boom after said derricking angle detection sensor detects that an angle of said horizontal boom with respect to ground reaches horizontal.

**10.** A method for operation control of folding a horizontal boom in a reach tower crane having an apparatus for extending or folding said horizontal boom, said method comprising the steps of:

(a) starting to lay said horizontal boom after a vertical boom and said horizontal boom are retracted and a length detection sensor detects that both of said booms are retracted to their shortest length as well as a derricking angle detection sensor detects that said vertical boom is erected at a predetermined derricking angle;

(b) start to unlock by a second locking apparatus after said derricking angle detection sensor detects that said horizontal boom is at a maximum angle of laying;

(c) starting to turn said horizontal boom by driving a turning motor after a detection sensor detects that the locking is completed by said second locking apparatus;

(d) start to lock by a first locking apparatus after a turning angle detection sensor detects that said turning motor has turned to a predetermined turning angle; and

(e) starting to lay said vertical boom after said detection sensor detects that locking is completed by said first locking apparatus.

**11.** A method for operation control of a reach tower crane having an apparatus for extending or folding a horizontal boom, wherein a horizontal boom is derricked after a vertical boom is extended to a predetermined length.

FIG.1

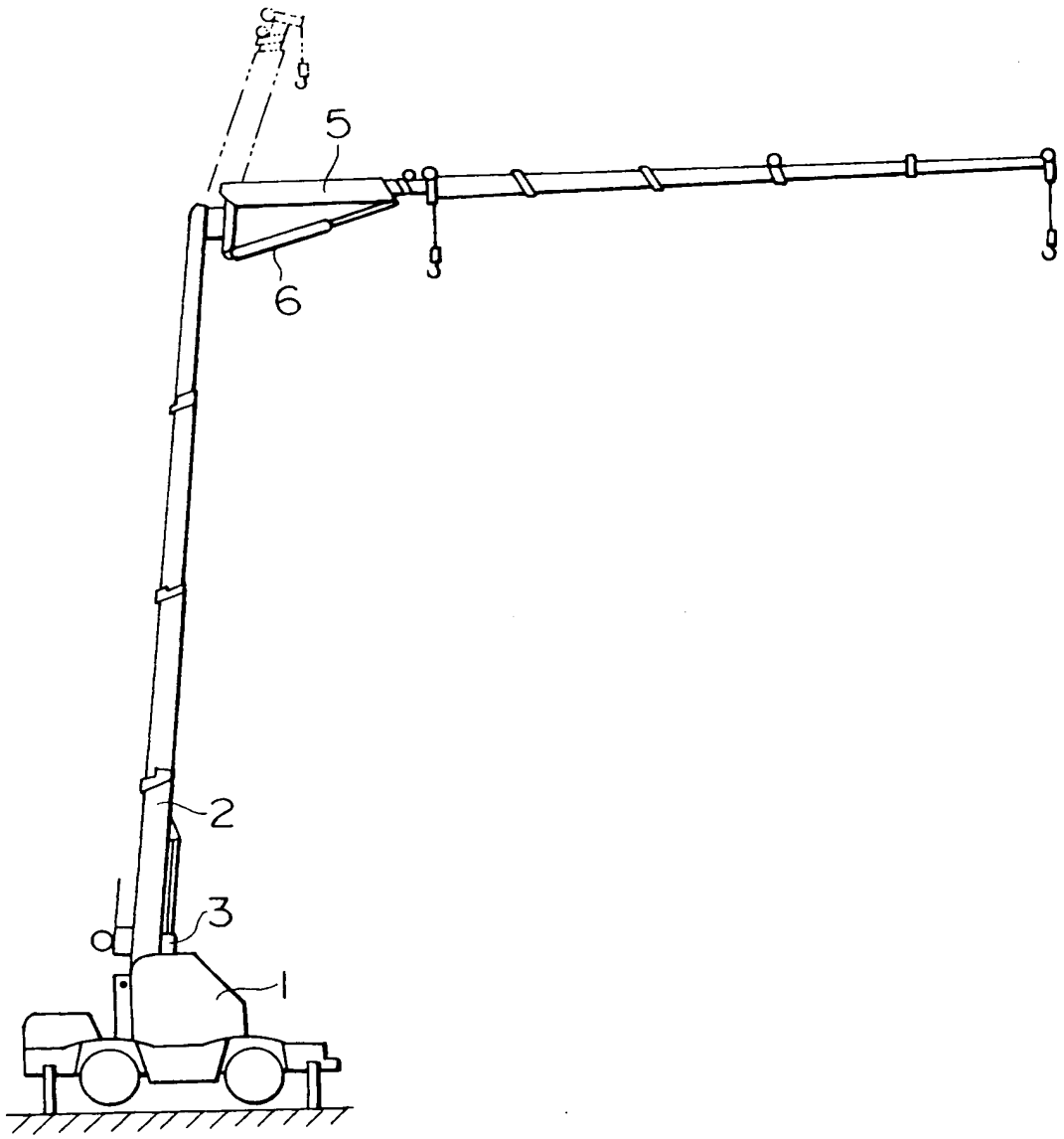


FIG. 2

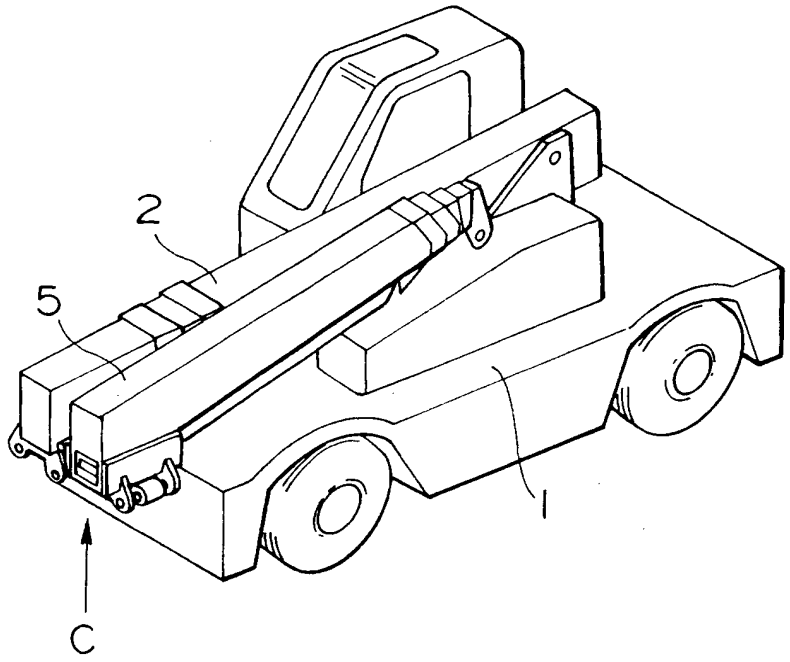


FIG. 3

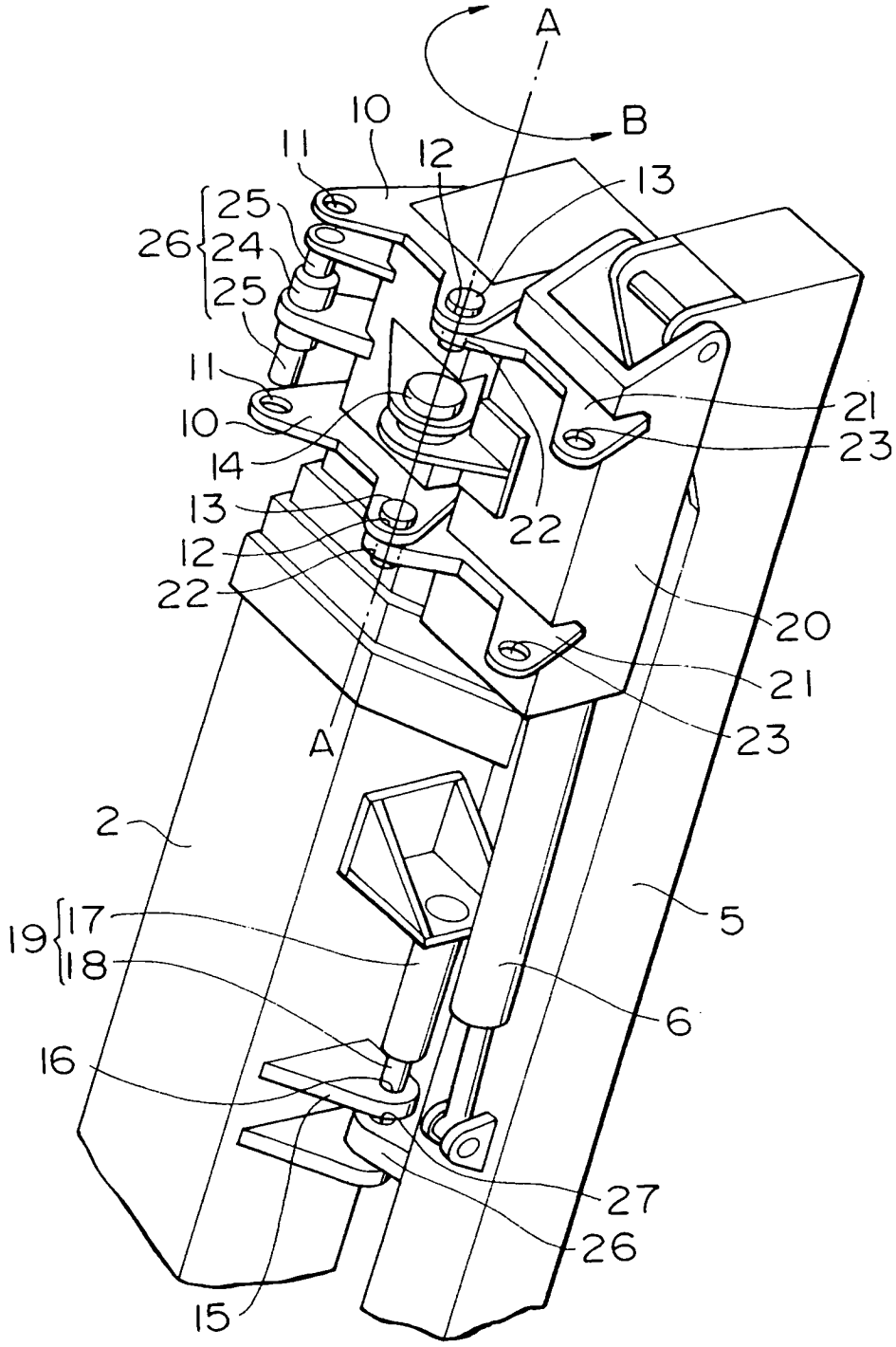


FIG. 4

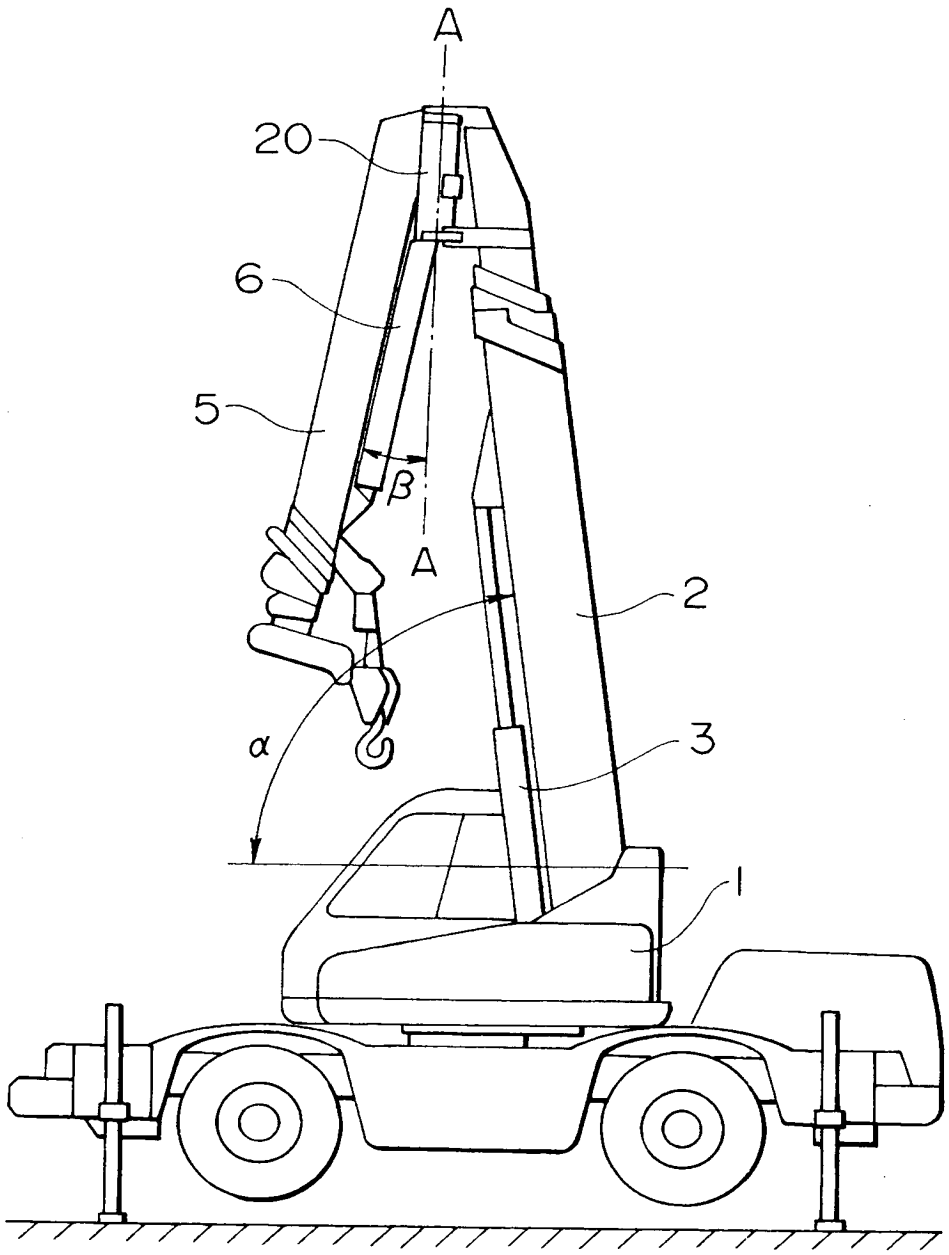


FIG. 5

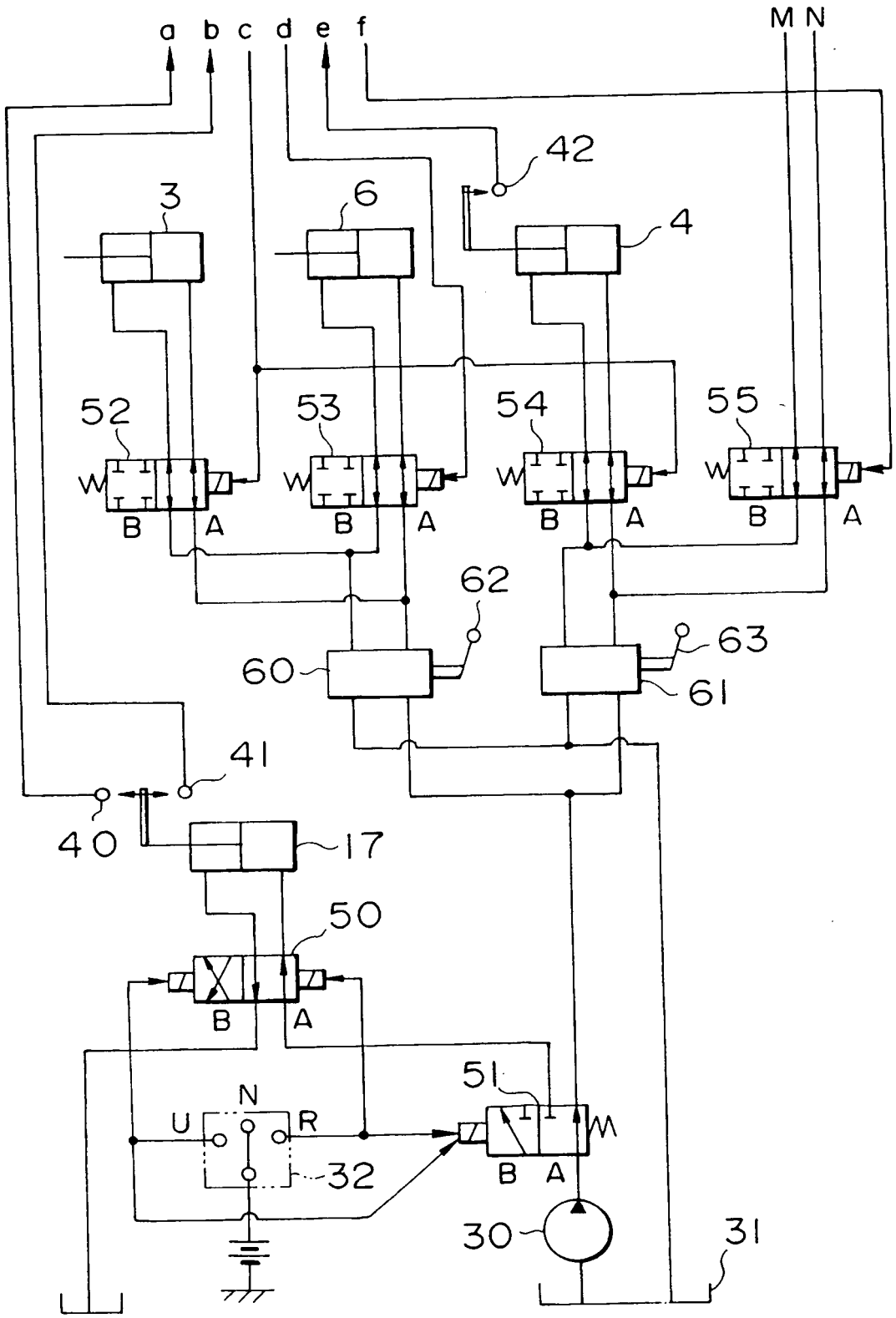


FIG. 6

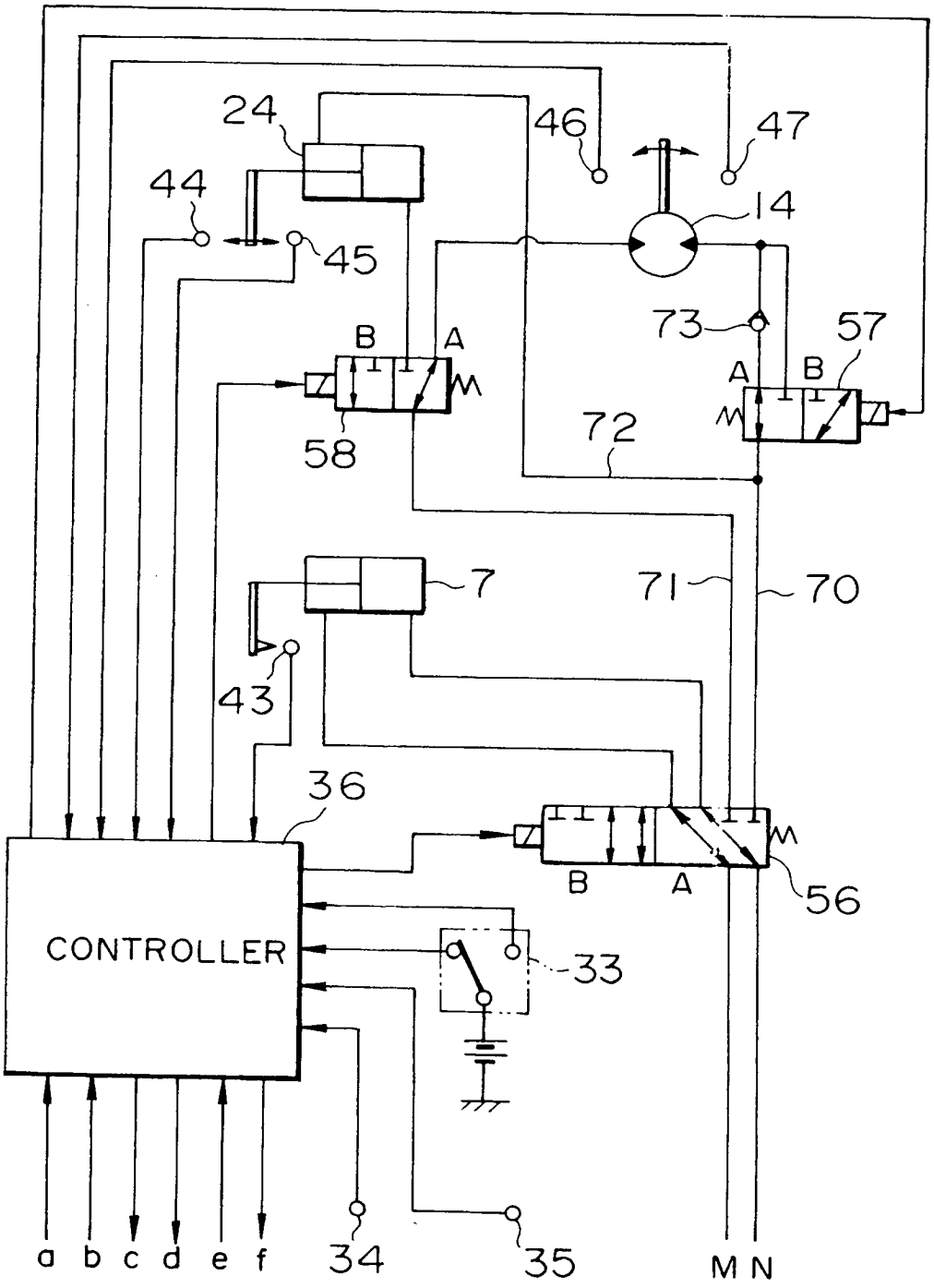


FIG. 7

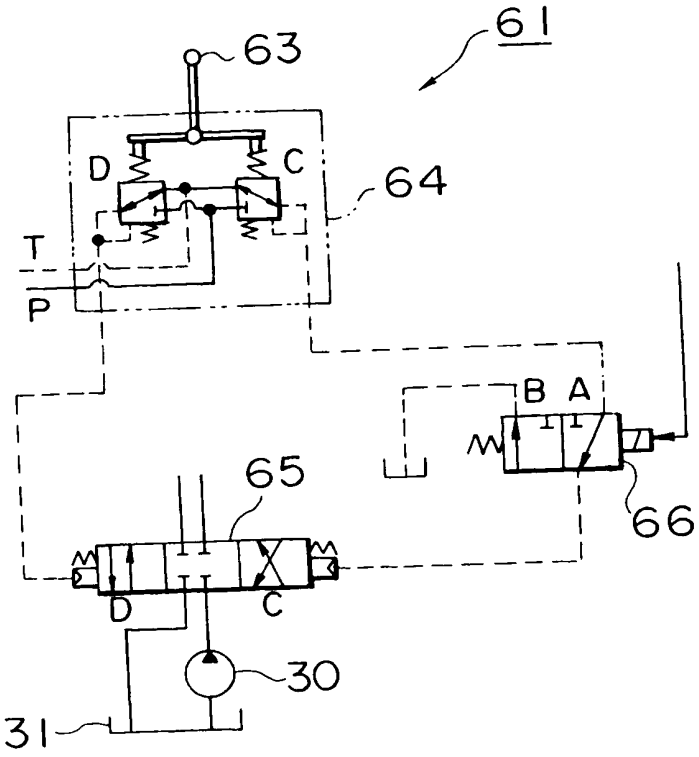



FIG. 8

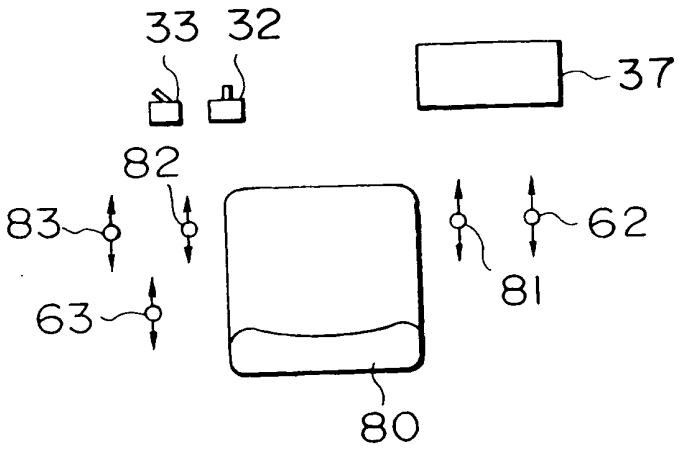


FIG. 9

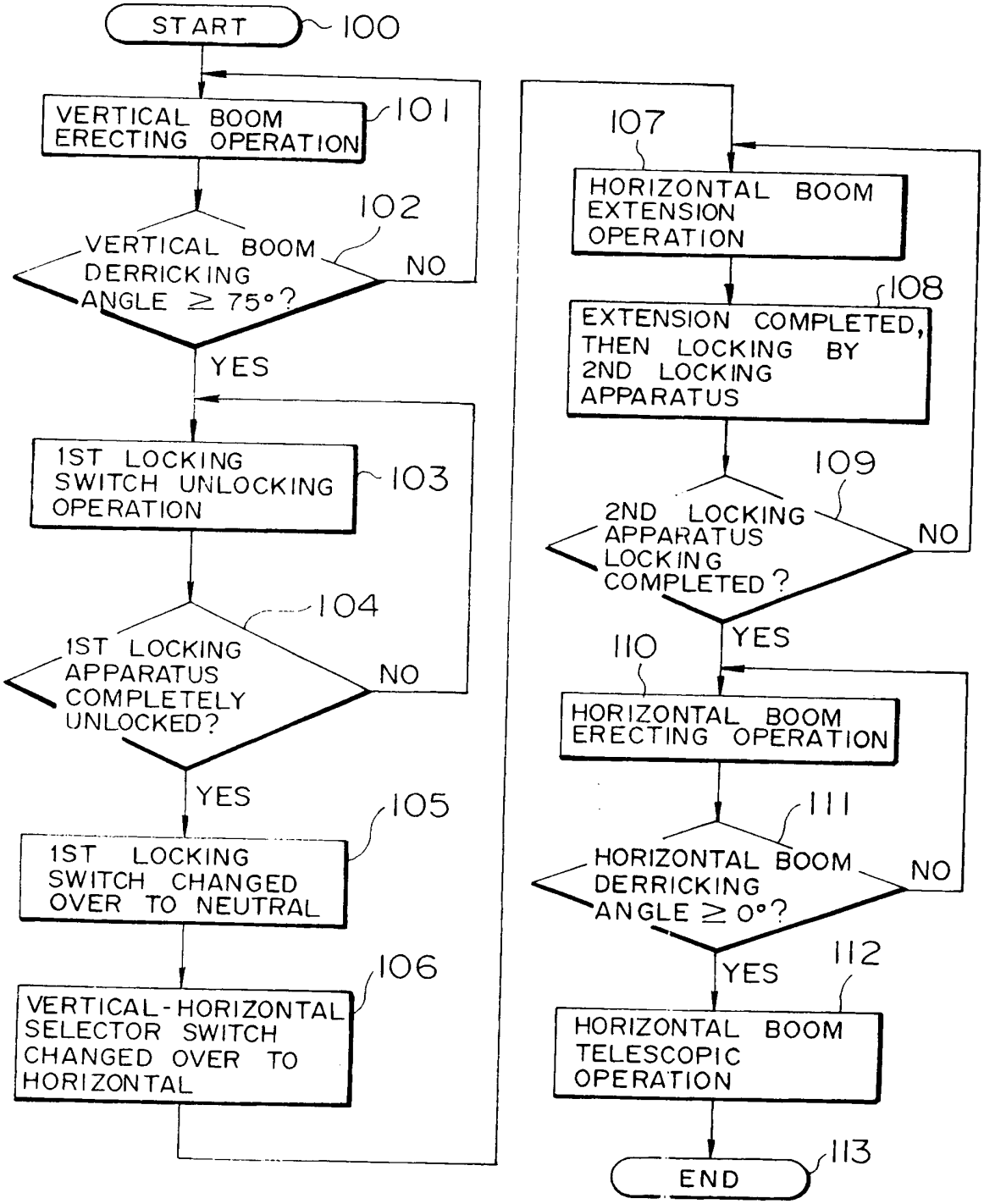


FIG. 10

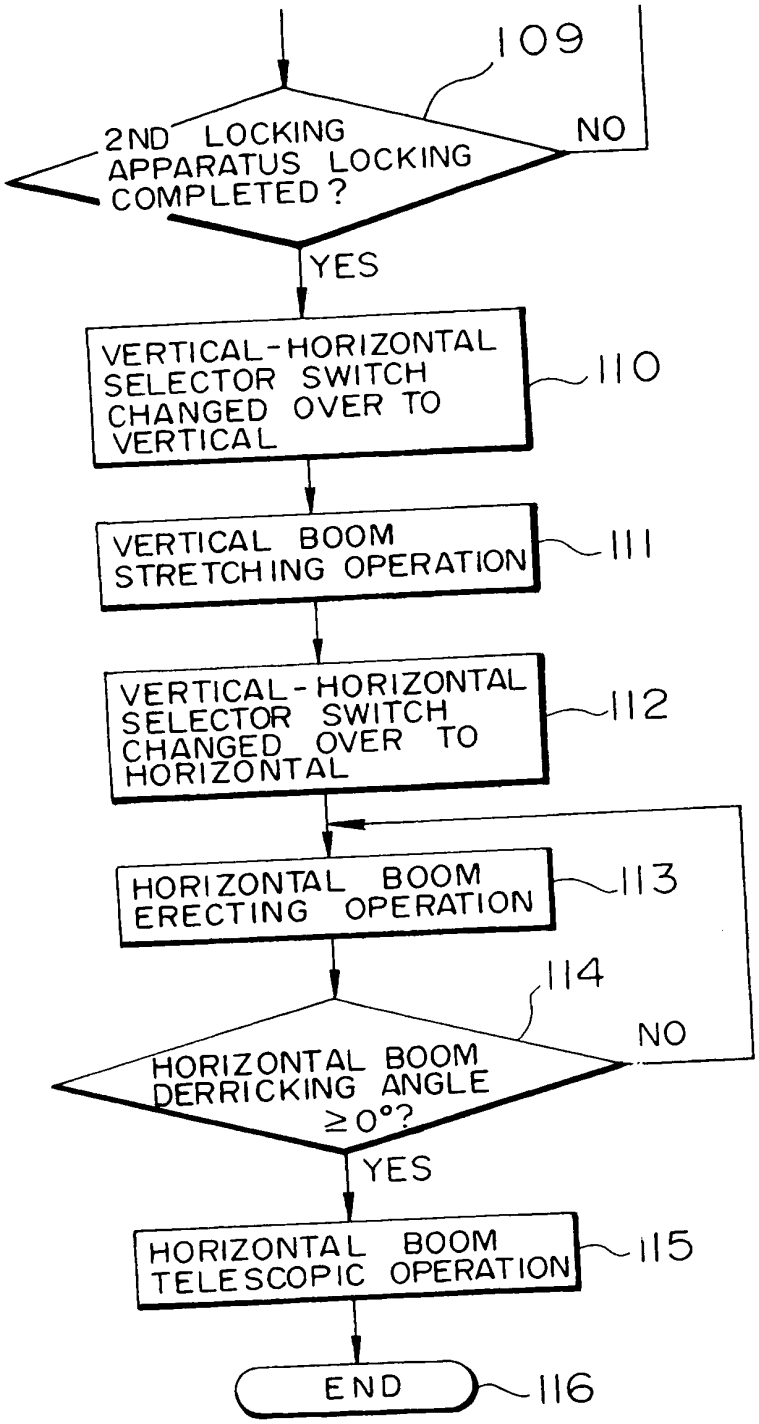


FIG. 11

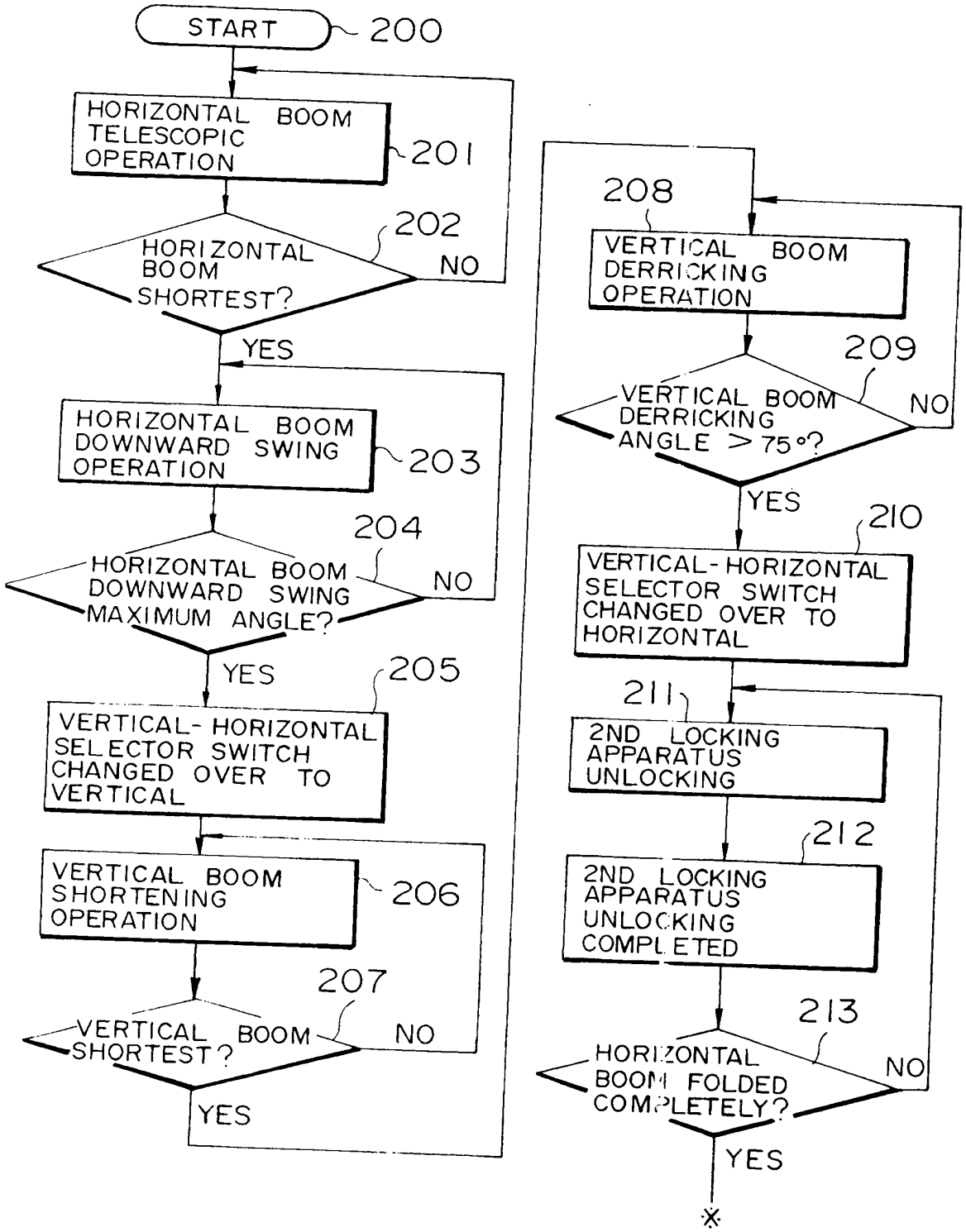


FIG. 12

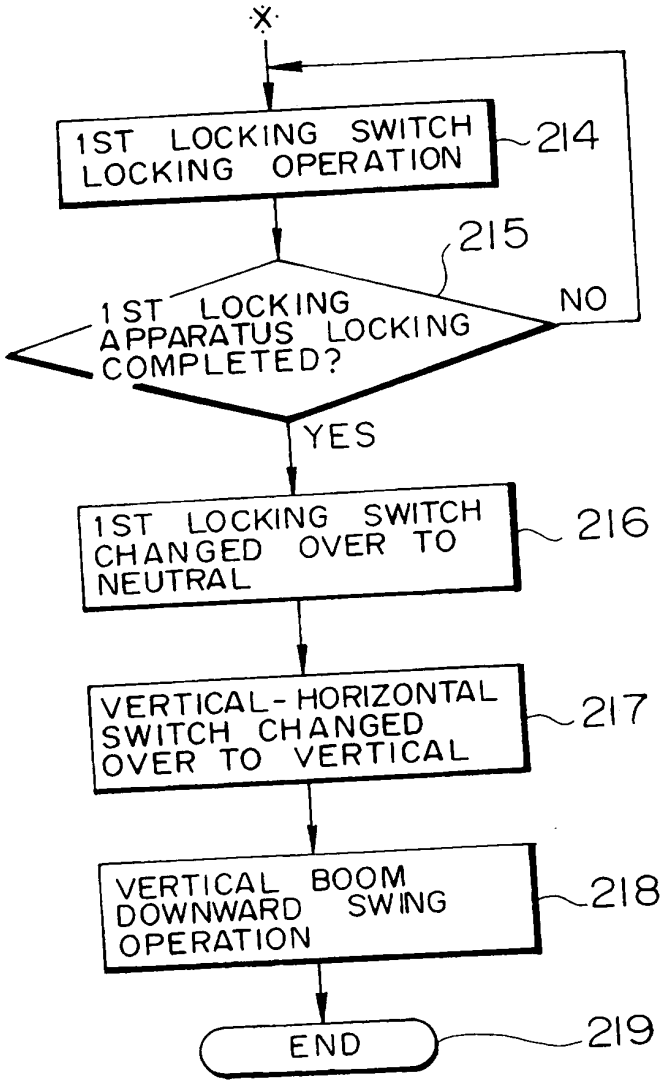
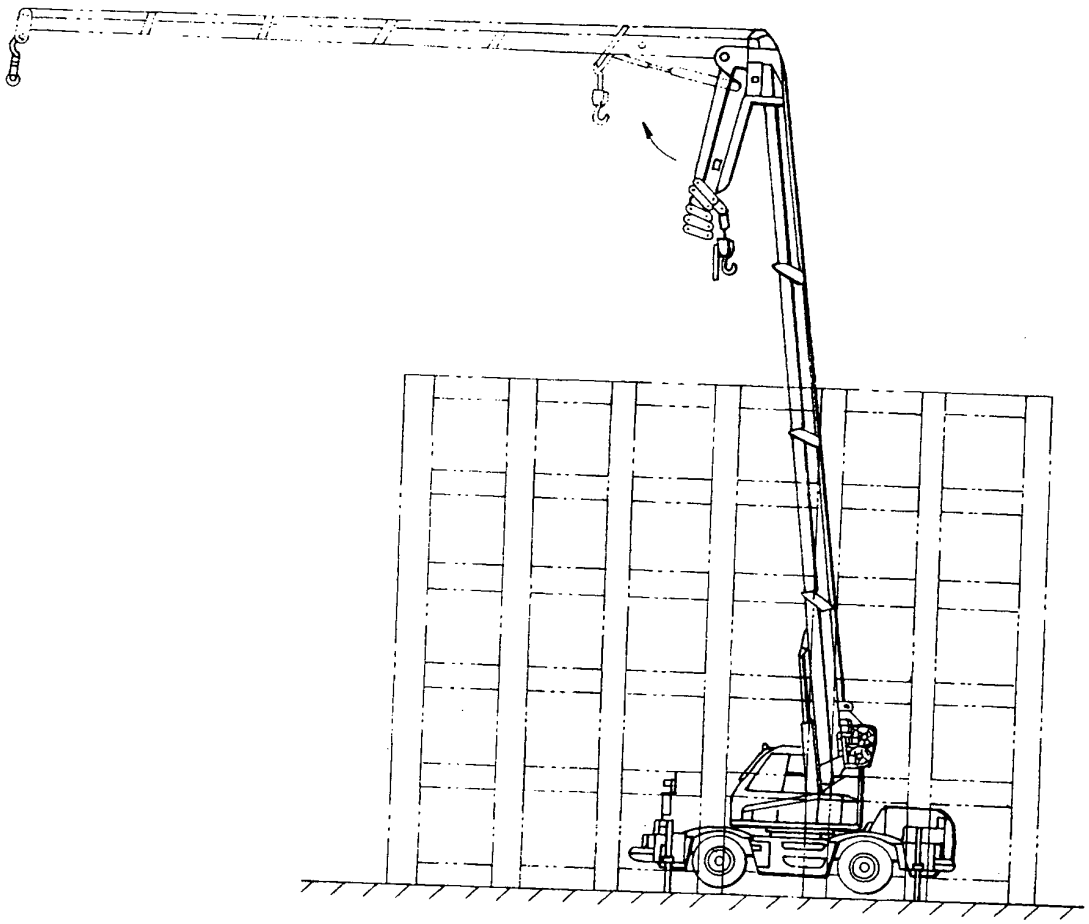


FIG.13



# INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP94/01874

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl$^6$ B66C23/26, 23/42, 23/68, 23/70
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
Int. Cl$^6$ B66C23/26, 23/42, 23/68, 23/70

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926 - 1995
Kokai Jitsuyo Shinan Koho 1971 - 1995

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP, B2, 3-4475 (Kobe Steel, Ltd.), January 23, 1991 (23. 01. 91), Line 41, column 12 to line 35, column 14, (Family: none) | 1-6, 7-8, 9, 10, 11 |
| A | JP, B2, 4-11476 (Takenaka Corp.), February 28, 1992 (28. 02. 92), Lines 1 to 21, column 4, (Family: none) | 1-6, 7-8, 9, 10, 11 |
| A | JP, A, 4-85298 (Tadano Corp.), March 18, 1992 (18. 03. 92), Line 17, lower right column, page 5 to line 12, upper left column, page 7, (Family: none) | 1-6, 7-8, 9, 10, 11 |
| A | JP, U, 63-41092 (Mitsubishi Heavy Industries, Ltd., Sairyo Engineering K.K.), March 17, 1988 (17. 03. 88), Fig. 4, (Family: none) | 1-6, 7-8, 9, 10, 11 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| January 26, 1995 (26. 01. 95) | February 7, 1995 (07. 02. 95) |
| Name and mailing address of the ISA/ Japanese Patent Office<br>Facsimile No. | Authorized officer<br>Telephone No. |

Form PCT/ISA/210 (second sheet) (July 1992)